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THE MANCHESTER

STEAM USERS' ASSOCIATION.

ESTABLISHED 1854.

MEMORANDUM BY CHIEF ENGINEER,

PRESENTED AT THE

ANNUAL MEETING

OF THE

GENERAL BODY OF THE MEMBERS,

HELD ON

TUESDAY, JUNE 18TH, 1901.

MANCHESTER:
TAYLOR, GARNETT, EVANS, AND CO., LTD., BLACKFRIARS STREET.
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MANCHESTER STEAM USERS' ASSOCIATION.

ACCUMULATED FUNDS, £23,000.

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MEMORANDUM BY CHIEF ENGINEER.

June 18th, 1901.

TO THE EXECUTIVE COMMITTEE.

GENTLEMEN,

As mentioned in the Annual Report, the Association has, in spite of new competitors and other adverse circumstances, again made substantial progress, and the number and types of boilers are now as stated in the following table :—

DETAILS OF BOILERS ENROLLED.

Boiler Type.	Total Number.	Oldest Boiler.	Average Date.
Lancashire and Galloway	3,702	1850	1884
Cornish	1,170	1845	1882
Vertical	1,077	1868	1890
Loco. Type	656	1864	1888
Marine Type	183	1865	1892
Externally Fired	154	1860	1883
Water Tube	90	1873	1897
Total	7,032		

The slight discrepancy between this number and that of the Annual Report is due to the two having been summarised from different lists, in which the entries are not all made on the same principle. The gains and losses will be seen from the following statement :—

Boilers built in 1900 and tested by the Association, and subsequently guaranteed	92
Ditto for shipment or not yet guaranteed	131
Total new boilers tested by M. S. U. A., 1900	223
Old boilers first inspected 1900, and guaranteed	410
Ditto and found unfit for guarantee	50
Total old boilers first inspected 1900	460
Total old and new boilers guaranteed for first time in 1900 ...	502
Total old boilers of members broken up or withdrawn in 1900.	335
Net gain of boilers during 1900	167

The largest increase has been recorded in water tube boilers, and a substantial decrease in the number of externally fired ones. This would have been matter for congratulation were it not that most of these boilers have not been broken up, but have left us to be taken over by insurance companies. As is well known, this Association looks on externally fired boilers, unless they are short or well stayed, as a fairly dangerous type.

Motor Cars with steam boilers are rapidly growing in favour, but their designers do not always seem to have a sound knowledge of boilers, and it has been my painful duty to have to refuse to guarantee some of them as being unfit for their intended working pressures. In their desire to cut down weight and save space, inventors often appear to have overlooked the question of safety, and it is only a wonder that certain of these boilers have not already become notorious by exploding, their margins of safety being much less than what is customary for even less dangerous objects.

There are, however, many motor car steam boilers of excellent design and workmanship, neither too heavy nor too weak, about whose safety there should be no doubt, and some makers have arranged with this Association to have all their boilers inspected, tested, and certified by us.

New Boilers and Engines.—The number of boilers and engines built under our inspection is steadily increasing. Not only do our members avail themselves of our services, but many boilers are inspected by us for outsiders and for shipment. The information which has accumulated with us ever since the days of Sir William Fairbairn places us in a position of giving the best possible advice in these matters.

Steel for Castings.—Recently trouble has arisen with reference to steel for boiler mountings. Some years ago, when high-pressure steam came into fashion, it was felt that cast iron was not a suitable material for the main junction valves, which frequently must be subjected to very intense stresses, due to the variations in the lengths of the steam pipes to which they are connected. It was, therefore, decided that these valves and other mountings should be made of cast steel. Fairly recently, however, it was found that this metal was not of the desired quality—that, in fact, a material with the name of cast steel was being sold, whose strength was very variable, and even fell as low as 6 tons per square inch. It also appeared to be less capable than cast iron of withstanding shocks. It was, therefore, decided not to accept this material; and as the word "cast steel" might legally be considered to embrace these alloys, we now stipulate "mild cast steel," about which term there can be no misunderstanding.

It must not be imagined that the substitution of these alloys for steel was only a question of price. One of the greatest difficulties which engineers have to contend with is that, in this country at least, complaints about steel castings being full of blowholes are far too frequent, and, unfortunately, only too true. This often entails rejecting a casting after it has been nearly completely machined; and that, again, may mean serious delay to the boiler

for which the casting was intended. If it were not for the fact that one or two steel works do turn out uniformly sound castings, it might almost be necessary to reconsider the whole question with a view to reverting to cast iron. This material, as is proved in Marine practice, is safe under the conditions of working to be found there, the boilers being almost invariably situated close to the engines, and connected to them by copper pipes. The result is that stresses due to vibration or expansion are thrown almost entirely on these steam pipes, which not infrequently fracture. Ashore it is not the steam pipes, which are generally of iron or steel, but the junction valves which most frequently fracture, unless they are made of a really tough material like steel, or if the pipes are suitably arranged with expansion joints or bends.

Steam Pipe Arrangement.—Unfortunately when designing a boiler, which includes the junction valve, nothing definite is known about the steam pipe arrangement, which may or may not throw excessive stresses on the mountings; and these, therefore, have to be made of a tough material like steel, at least when the pressures and the changes of temperature are high.

The danger is further increased by the opinion generally held, that steam pipes may be laid down anyhow to suit conveniences, quite ignoring that some of the most serious explosions have been directly due to bad design. In most of these accidents the expansion bends, or the general arrangement was such that water found a lodgment in some pocket; and, on being set in motion by opening a steam valve or a drain cock, this water was propelled with such energy that it shattered either the pipe or its valve. The very peculiar nature of this water hammer action is illustrated by a case in which the plug of water struck the brass valve of a junction valve, turned it inside out, and drove it through its seat into the boiler, which at the time had a full pressure of 150 lbs. per square inch. The valve casing was not fractured.

Isolating Valves, consisting of heavy balls or flap valves, are sometimes introduced into steam pipe ranges. No case is yet known where they have come into action, but it is to be feared that if they were set in motion by a sudden flow of steam, they would fly against their valve seat and shatter it.

Horizontal Lengths of Pipes, with an upward bend at one of the ends, have proved themselves extremely dangerous under the following conditions. If such a horizontal length of pipe and its vertical continuation be full of water, and if then steam be turned on so as to be in contact with the water in the vertical pipe, and if also the water in the horizontal length be allowed to drain out until it sinks below the inside top of this pipe, then, on account of condensation, the steam rushes into the space above the water, sweeping up

waves (as shown in Fig. 1), which seem to be endowed with such

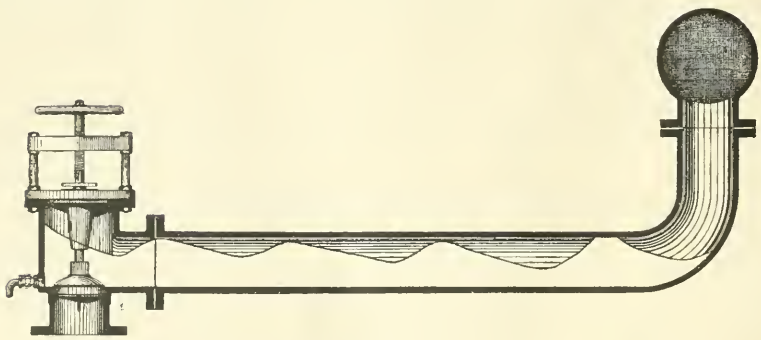

FIG. 1.

energy that they set the whole mass of water into violent motion, causing it to oscillate backwards and forwards, until at last it strikes against the valve with such force as to shatter it. If the pipe be a long one, the water may even separate itself at any point of its length, and on coming together again may shatter the pipe at the point of meeting.

EXPANSION BENDS SKETCHES.—In designing a steam pipe arrangement, one has to bear in mind that allowance must be made for expansion, and the bends which naturally suggest themselves for this purpose must be so arranged that water cannot lodge in any part of the pipe.

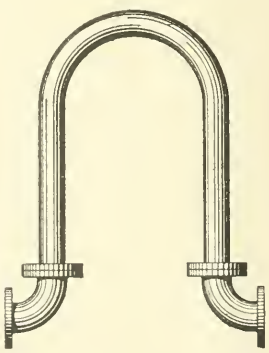

FIG. 2.

The more general arrangements are shown in Figs. 2, 3, and 4, while Figs. 5 and 6 are more unusual. These bends or loops should, if possible, be placed horizontally, or slightly sloping in the

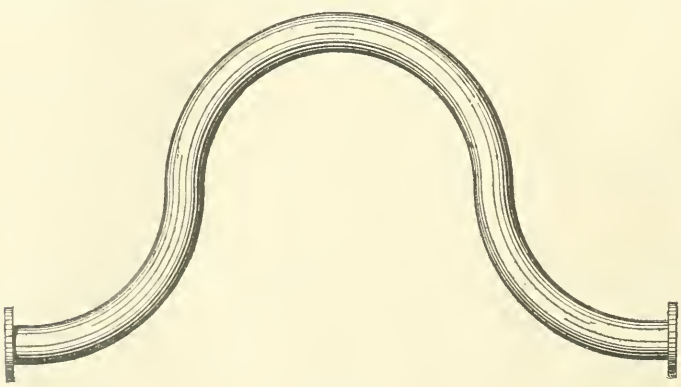

FIG. 3.

direction of the fall of the straight pipe. Fig. 5 is therefore convenient where there is a change of level slightly exceeding the

diameter of the pipe. If the bends are placed vertically, small elastic pipes should connect their lower parts, so as to allow water

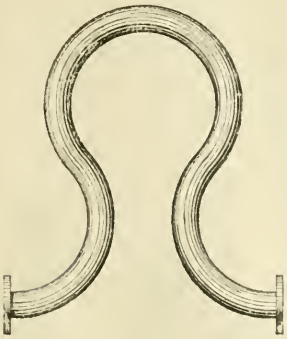

FIG. 4.

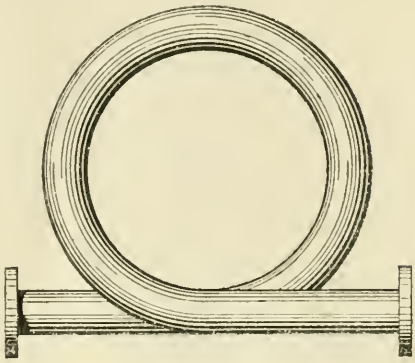

FIG. 5.

to drain past. If the bends hang downwards automatic drains should be fitted.

ELASTICITY OF BENDS.—A bend is more elastic than a straight pipe of equal height, so that two parallel pipes (as in Fig. 2), connected not by a bend but a casting, would be the most rigid of all the arrangements shown. Let the permissible amount of spring of this arrangement be represented by 2, then the loops (Figs. 3, 4, and 5), consisting only of bends, would spring six times as much, while Fig. 2, consisting of $\frac{2}{3}$ straight pipe and $\frac{1}{3}$ bend, would spring $2\frac{2}{3}$. In the helical loop shown in Fig. 6 the stresses are torsional, and the elasticity, as might be expected, is greatest, being represented by 21. The permissible amount of stretching of any of these bends is directly proportional to the mean height of the loop, and inversely proportional to the square of the diameter of the pipe, and is quite independent of the thickness of its metal. But the force required to stretch a loop is proportional to the thickness of the metal and to the square of the diameter of the pipe. If, therefore, a weak point, such as a cast-iron junction valve, has to be relieved of the stresses which some strong steel pipes are exerting on it, one would insert either a copper bend or a steel bend of the thinnest permissible metal, but then all the bending would be thrown on these parts. If the only object of the design is to take up the expansion of a long pipe, it is generally best to make the bends of the same material and thickness as the straight pipes.

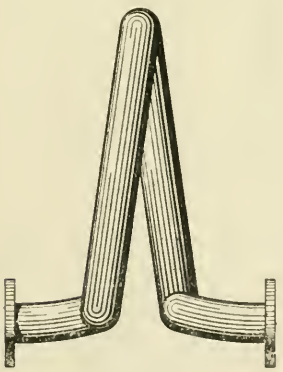

FIG. 6.

STEEL AND COPPER BENDS.—Steel is more difficult to bend than copper, but, as is well known, the elastic limit of copper is very

low, and it is easily shown that even the mildest sheets of steel or wrought iron have more spring in them than have copper ones. There is also no reason to believe that copper suffers less than steel by repeated bendings beyond its elastic limit; at any rate copper pipes grow brittle after years of use and have to be annealed. It would therefore appear that steel pipes, though they require a greater force than copper pipes, may be pulled through a greater distance without injury to themselves. Assuming the maximum permissible stress, just below the elastic limit, to be 10 tons for steel and 3 tons for copper, we get the following permissible stretches of the various loops. The diameter or height of each is assumed to be 4ft., and the pipe diameter 6in.

Material.	Two Straight Pipes.	Fig. 2.	Figs. 3 and 4.	Fig. 5.	Fig. 6.
Steel	0·21	0·42	0·74	0·74	2·60
Copper	0·12	0·23	0·41	0·41	1·45

Expansion Bends on Long Pipes.—It has already been explained that if the bends are stiff the valves and straight pipes to which they are attached will be strained, and if these pipes are very long, and if they have some liberty of side motion, their bending will give a certain amount of relief, and the values in the table may then be doubled, except, of course, for the helical loop in Fig. 6, which cannot cause any side bending. As the movements of the pipes are due to heat, it is, of course, permissible to arrange for the bends being as much stretched when cold as compressed when hot. This again allows of the values in the table being doubled, and we thus find that a four foot copper bend, 6in. in diameter (as shown in Figs. 3, 4, and 5), is capable of relieving an expansion amounting to 1·6in., which is about sufficient for a length of 50ft.

Expansion Diaphragms.—These are quite unsuitable for high pressures except in the form of small copper corrugations.

Expansion Joints are not often used, not only because of their expense and liability to leak, which is a very strong objection at stations where steam is required day and night, but because in most situations the thrusts which they exert are a great inconvenience. A form of expansion joint which overcomes this difficulty consists of a thimble, which is attached to the end of the pipe, and passes through two glands of a T pipe. The thimble has numerous slits on its enclosed part. It is clear that there will be no steam pressure thrust, but the arrangement is only suitable at corners, where in most cases relief is hardly required.

It will thus be seen that the design of a steam pipe arrangement is not so simple a matter as it would appear, and as steam pipes are

by Act of Parliament embraced in the term steam boilers, it would be an advantage to our members when laying down boilers to have their steam pipes reported upon.

Scale and Corrosion.—As mentioned in my last year's Memorandum, we have now established a chemical laboratory, and have during the last twelve months carried out many analyses on feed waters, and are now in possession of full information as to the mineral and corrosive constituents of most of the water supplies to large towns. Those of our members using these waters are receiving revised instructions as to treatment. Many members whose works are situated in other districts have also had their waters analysed and reported upon by us.

A very general request is for information as to how scale can be got rid of entirely, and how the expense of scaling can be obviated, to which there is, of course, only one reply, viz., that the water should be treated before it is fed into the boiler, and not unnaturally further inquiries are then made as to the relative costs of working feed-water purifiers. Information on the subject is rather conflicting, and it was therefore decided to send our chemist on a tour of inspection of Works where various purifiers could be seen in operation, and a brief summary of his report is contained in the following pages :—

Cost of Working Boilers without Purifiers.—In order fully to understand the nature of the inquiry, it has been thought desirable to make a rough estimate as to the annual cost of installations with from one to seven boilers of 8ft. diameter, costing £800 with setting, and using, in one case, pure water, in the other cases., sedimentary water. The interest on the first outlay is taken at 3 per cent., and the interest on the sums set aside for depreciation is also taken to be 3 per cent. On account of the assumed rapid wear of the

Nature of Feed.	Pure.	Very Sedimentary Water.						
Boilers at work	1	1	1	2	3	4	5	6
Spare boilers	0	0	1	1	1	1	1	1
Assumed life of boilers	50	15	40	40	40	40	30	20
Interest on first cost £	24	24	48	72	96	120	144	168
Depreciation £	7	43	21	32	42	52	100	209
Scaling and cleaning @ 30/- £	2	6	31	47	62	78	78	78
Chemicals £	2	10	10	20	30	40	50	60
Totals £	35	83	110	161	230	290	372	515
Totals per working boiler £	35	83*	110	80·5	76·7	72·5	74·4	85·8

* Note.—The actual cost would be much greater, as the works would be closed down for 4 weeks per annum.

hard-worked boilers, their lives are supposed to be relatively short. The best worked boiler without scale is supposed to last 50 years, requiring no scaling. The worst cases would be a boiler worked, say,

for stretches of three months, because there is no spare boiler, and this is supposed to last only 15 years. Even in six weeks the scale is supposed to have grown thicker than is desirable. This would reduce the life of six and one spare boiler to 20 years. In the next best lot, having one spare boiler for every five, each gets cleaned every five weeks, lasting, say, 30 years, while all the others are scaled every four weeks, lasting, say, 40 years.

The probable ages which the boilers may attain are based on the assumption that the gradual accumulation of scale during the time that each of these boilers will be allowed to run will increase the wear and tear, and will have the effect of shortening the life of a boiler, and also that those installations where the boilers get little rest will not be scaled so well as others. The cost of scaling includes the operation of laying off the boiler.

It will be seen that the annual cost (chiefly interest) for a boiler using pure water with only such chemicals as prevent corrosion, would be about £35, whereas boilers using sedimentary waters would cost from £37 to £75 more. If, then, it can be shown that the interest, depreciation, and working expenses of a water-softening apparatus per boiler amounts to less than these extra expenses, its advantage in connection with very sedimentary water is demonstrated.

A charge of 30s. for cleaning boilers is fairly high, but even in works where it is less, the extra cost of boilers using sedimentary water is not much reduced. The table will be useful as showing that where the question arises as to whether a spare boiler or a water softener is to be put down, the latter would seem to be the more advantageous, and the information which our chemist (Mr. Baron) collected will throw more light on the subject.

Summary of Report on Fifteen Water Softeners.

Except where the installations were practically new, or where they were under the eye of a chemist, the manufacturers' instructions were rarely adhered to. In one case the quantity of added lime had been doubled, making the water harder than it was before treatment; in another case the settling tanks had never been emptied, with the result that the sediment had filled the tanks, and was as hard as a rock. These experiences are to be regretted, because the water softeners are designed so as to be worked by the fireman, who, if he only receives proper instructions, is quite capable of carrying out the necessary manipulations.

The principle of water softening is a simple one. To remove the temporary hardness, caused by dissolved carbonate of lime and magnesia, a certain quantity of burnt lime has to be added to the water, when precipitation should occur. To remove permanent hardness carbonate of soda should be added, and further precipitation

should occur. In practice it is found that this precipitation is slow, so that the settling tanks have to be made large, or filters have to be used, which are, of course, inconveniences, and the various patentees have tried to overcome them, as follows :—

1. The treated waters are mixed with old sediment.
2. They are mechanically stirred.
3. They are stirred by air jets.
4. They are heated.
5. After having settled, the nearly clear fluid is treated with carbonic acid which dissolves the sediment.

The treatments under 1 and 2 are fairly satisfactory, and, particularly if filters are also used, lead to a very important reduction in the height and size of the settling towers. These are generally fitted with baffle plates, &c., though by increasing the velocity and changing the courses they cannot be looked upon as tending to expedite clarification of the water.

The treatment under 3 is effective as regards clearing the feed, but as the water thereby gets impregnated with air, the water is made more corrosive than it would otherwise be.

If, as in 4, the water is heated, the chemical reaction is rapidly completed, and the scale deposited. If the heating takes place in an economiser the tubes rapidly get choked with soft scale, and have to be cleaned frequently, but little or no scale gets into the boiler. If the water is passed through tubular heaters these take the deposit, and, unless special provisions are made, its removal is troublesome. To heat newly-purified water by live steam from the engine is an objectionable practice, for the cylinder grease combines with the final precipitate, and forms a light pasty substance, which adheres to the heating surfaces and causes bulges or collapses. If, as in the case of the Stanhope and the Wollaston purifier, the feed is heated by live steam before treatment, the cylinder grease and all the sediment appear to get removed. There must, however, be a considerable loss of heat by radiation, which makes it appear desirable to cover the tanks, or otherwise keep them warm.

The treatment 5 is open to the same objection as that of 3.

Some water softeners work continuously; others are so arranged that a tankful is prepared at a time. Then, of course, the measuring of the chemicals is a simple matter, whereas if the process is continuous the devices for obtaining a steady supply of chemicals are numerous and ingenious. The lime is either in the form of milk of lime or lime water, the latter being very bulky. In some softeners the flow depends on the size of nozzles, in others on the difference of density, and in others, again, small measured quantities are tipped into the feed by mechanical means. Probably the old arrangement of using adjustable pumps is the cheapest and most reliable.

Porter Clark Continuous Water Softener.—This is the oldest, and best known for treating only temporary hardness. Three installations (A, B, and C) were visited.

A. This installation is capable of dealing with about 3,000 gallons per day, but is only used for 2,000. It consists of (*a*) a lime mixer in which two paddles are worked by an engine, constantly stirring up milk of lime, which is prepared by adding burnt lime to water. No definite information could be obtained as to the quantity of lime, except that 1 cwt. was used at a time. The milk of lime is pumped into the water-supply pipe, and the mixture is delivered into (*b*) two mixing cylinders 4ft. diameter, which are also agitated by engine power so as to ensure thorough mixing. From these cylinders the water passed through (*c*) four 2ft. filters, whose preparation entails much labour, and then into two tanks (*d*), each occupying a floor space of 36 × 20 feet. In the second of these tanks caustic soda is added, which converts the clear water into a turbid one. The object of this last proceeding was not very clear, and may have been necessary for trade purposes, but if it was intended to remove any permanent hardness it would have been better and cheaper to add soda ash, not caustic soda, to the milk of lime. The cost of this installation was £400, without the two large tanks which constitute the roof. The total floor space covered is 1,526 square feet. The following is the analyses of two samples before and after treatment, but they must have been taken on different days, for the process could not diminish the amount of sulphuric acid and hydrochloric acid, which, as will be seen, are much diluted.

Composition of Water.	Before Softening.	After Softening.	Change.
	Grains.	Grains.	Grains.
Calcium carbonate	11·512	1·034	10·478 loss
Calcium silicate	0·836	2·407	1·571 gain
Calcium sulphate	1·556	2·124	0·568 gain
Magnesium carbonate	5·876	4·831	1·045 loss
Ferric oxide, etc.	0·472	0·199	0·273 loss
Scale-forming minerals	20·252	10·595	9·657 loss
Sodium chloride	5·703	5·562	0·141 loss
Sodium sulphate	10·500	8·440	2·060 loss
Total soluble salts	16·203	14·002	2·201 loss
Total mineral matter	36·455	24·597	11·858 loss
Carbonic acid gas	6·94	5·98	0·96 loss
Oxygen gas	0·66	0·66	0·0

Treatment required per 1,000 gallons—Pure lime, 1·5 lbs.; Pure soda ash, 0·2 lbs. The actual treatment could not be determined.

As will be seen, in spite of the addition of lime, the free carbonic acid has not been much reduced; this is doubtless due to the large open tanks, the water being thus in contact with the air, and absorbing almost as much carbonic acid as was taken out in the process.

B. In this installation there were no filters. Lime and soda for 24 hours' treatment were mixed in a cylinder 4ft. diam. 15ft. high, and kept agitated by paddles, driven by an engine which also worked the pump which delivered the above mixture into the water supply. This water entered the mixing tower at the top, and was drawn off at the bottom and delivered into the bottom of a settling tower 13ft. diam. 22ft. high. It then overflowed into a feed well. No information as to cost or quantity treated was obtained, and nobody seemed to take an interest in the working. The boilers were said to have more scale than when no softener was used, which is quite possible if too much lime were added.

C. This installation is capable of treating 13,000 gallons per hour, and includes filtration, which, of course, involves a fair amount of labour. The tank for preparing the milk of lime is 5ft. 10in. by 5ft. 4in. and 6ft. high. It is provided with engine-driven paddles and a pump. The water and milk of lime pass into the top of the mixing tower 5ft. diam. and 23ft. high, and from the bottom they pass into the bottom of another tower of the same size, and overflow to four filters 2ft. square. About 2 cwt. of lime are added per 80,000 gallons.

Stanhope Continuous Water Softener is illustrated in Fig. 7, for which the block has been kindly lent by the Company. Two installations (*D* and *E*) were visited, but one was not at work, and the other had been adapted for special purposes.

D is capable of treating 3,000 gallons per hour, and covers a floor space of 13ft. by 11ft. 6in. The water supply enters a distributing tank (*a*), the inflow being regulated by a ball valve actuated by the height of the water in the feed tank. The distributing tank has three outlets, whose areas are all carefully adjusted so that relatively the right proportions shall flow into (*b*), the lime tower into (*c*) the soda tank, and into (*d*) the mixing pot, the overflow from (*b*) and (*c*) joining (*d*). Lime is placed in (*b*) and is agitated, but in such a manner that the top of this tank is undisturbed, and only clear lime water, not milk of lime, overflows into (*d*) the mixing pot. The amount of soda from (*c*) also depends on the amount of water flowing into it. From (*d*) the mixed water passes into the first settling tank (*e*), where most of the sediment is deposited, and it then passes into a tower (*f*) fitted with baffles and a filter, from which it overflows into the feed tank.

E. The other installation was similar but larger, and need not be described.

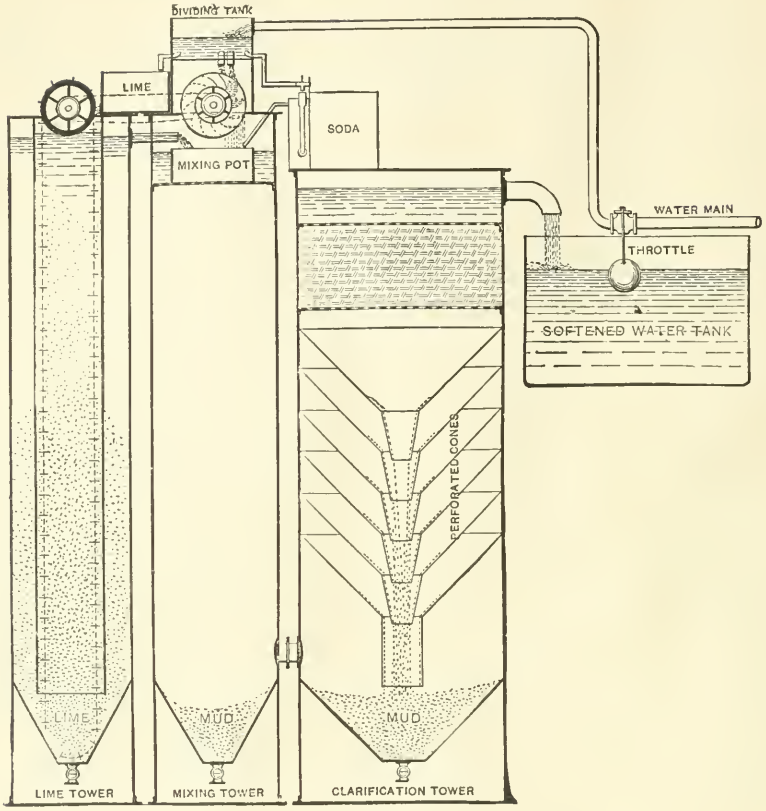

FIG. 7.

The Stanhope Company have also a combined feed softener and heater, but no installation was visited. The combined action of chemicals and heat ought to be very efficient.

ATKINS CONTINUOUS WATER SOFTENER is illustrated in Fig. 8. It only removes temporary hardness. Two installations, F and G, were visited, but in neither case were the patent filters in use, their tanks being filled with wood shavings.

It would appear that the baffles in the settling tank effectively prevent a settlement, and also, that in case of the water supply being checked, the lime water would still flow on at its original rate, and the result would be very irregular and unsatisfactory.

F. This installation treats 500 gallons per hour. The lime tower *(a)* is 2ft. diam. and 6ft. high. The clear lime water as well as the supply flow into the mixer *(b)*, and thence into the settling tank *(c)*, which is 7ft. long, 3ft. wide, and 5ft. high, and then into the filter tank, which measures 2ft. 3in. by 3ft. 3in. and 4ft. high. The floor space covered about 35 square ft. It was stated that the hardness was reduced from 15 to 7 grains per gallon. Ten pounds of lime are used for 60,000 gallons per week.

G. This installation was slightly larger than the above, and is said to have cost £115.

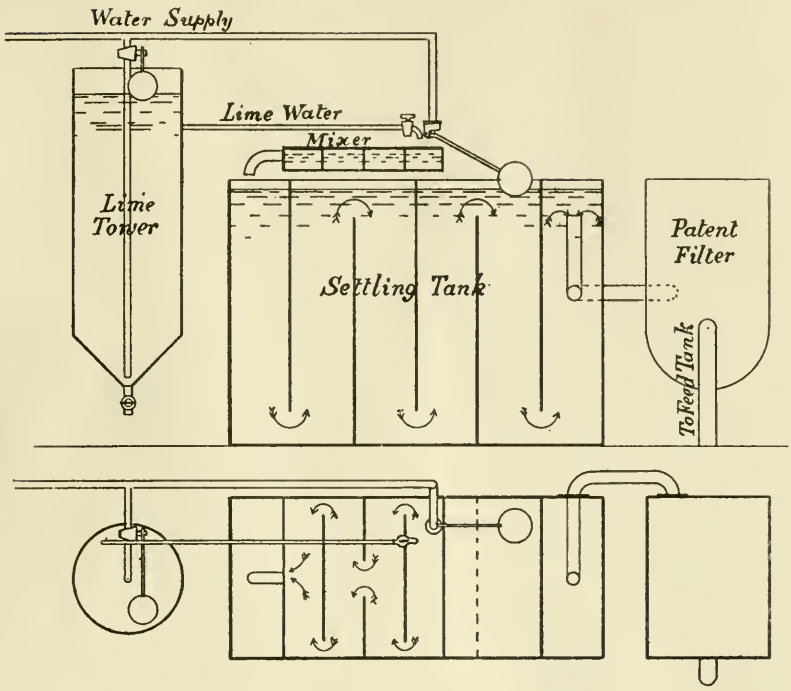

FIG. 8.

It was found choked with lime deposits, but was apparently got into working order after the inspection, and the two following samples were submitted for analysis. As will be seen, the hardness was not decreased, but increased from about 18 to 60, this being doubtless due to the ball tap on the lime tower being too full open, or the tap on the settling tank too much closed, or perhaps the lime water was not clear.

Composition of Water.	Before Treatment.	After Treatment.	Change.
	Grains.	Grains.	Grains.
Calcium carbonate	13·863	38·920	25·057 gain
Calcium oxide (lime)	0·0	14·300	14·300 gain
Calcium silicate	2·062	3·591	1·529 gain
Calcium sulphate	1·625	2·121	0·496 gain
Magnesia	0·0	0·266	0·266 gain
Ferric oxide, &c.	0·447	0·987	0·540 gain
Scale-forming minerals	17·997	60·185	42·188 gain
Calcium chloride	1·331	2·114	0·783 gain
Magnesium chloride	0·672	0·0	0·672 loss
Sodium chloride	0·479	0·476	0·003 loss
Soluble salts	2·482	2·590	0·108 gain
Total mineral matter	20·479	62·776	42·297 gain
Carbonic acid gas	9·71	0·0	9·71 loss
Oxygen gas	0·66	0·66	0·0

Treatment required, 1·8 lbs. lime, 0·2 soda ash per 1,000 gallons. Apparently 5½ lbs. of lime were added and no soda.

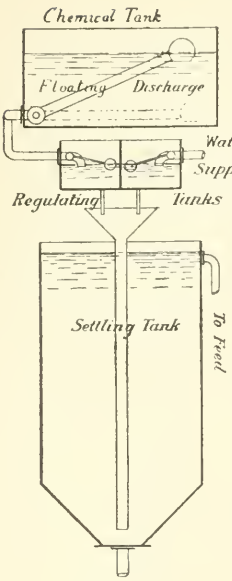

FIG. 9.

TYACKE CONTINUOUS WATER SOFTENER is illustrated in Fig. 9. Only one installation (*H*), and that a small one, was visited. It occupied a floor space of 3ft. 8in. diameter, and treats about 200 gallons per hour, but only for temporary hardness.

H. There are two chemical tanks (*a*) 2ft. × 4ft. × 2ft., which are alternately filled with water and a little lime. This lime water is clear. A connection is opened which allows a floating discharge pipe to deliver this water into the regulating tank (b_1) in which the water level is kept constant by a ball valve, and the outflow through a carefully-gauged nozzle is also constant. The water supply enters the adjoining regulating tank (b_2), and also flows out through a gauged nozzle. These waters are then carried to the bottom of the settling tank (*c*), 3ft. 6in. diam., 6ft. high, and pass upwards and through a bed of shavings overflowing to the feed tank. This apparatus could be used for treating permanent hardness by adding soda to the lime water.

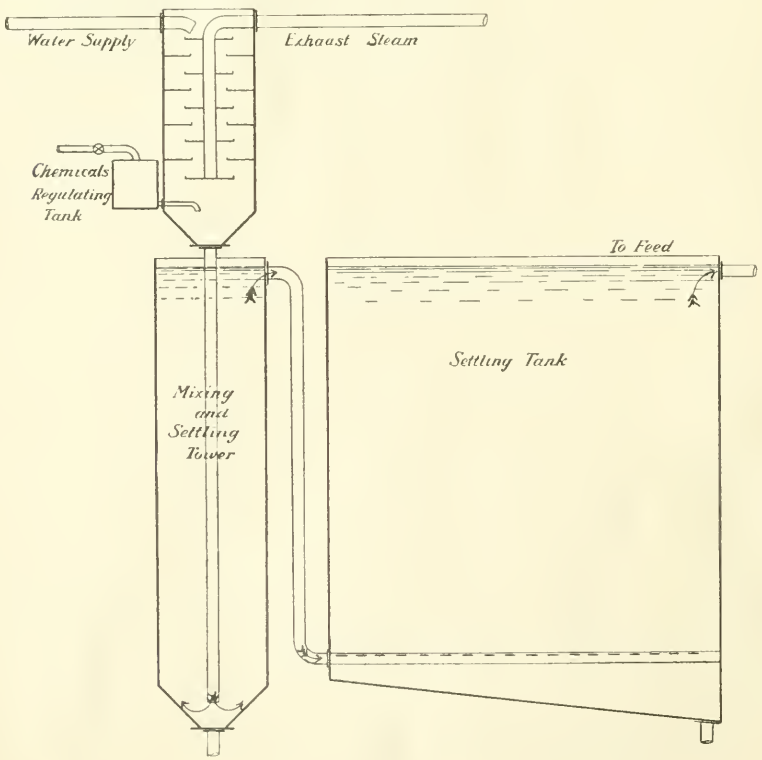

FIG. 10.

The fireman attended to the apparatus, which worked all right, reducing the hardness down to 6 grains per gallon.

Wollaston's Continuous Water Softener and Feed Heater Combined. (*See Fig. 10*).—(*I*) One installation was visited. The water supply and exhaust steam enter a vessel (*a*) fitted with trays, and into the bottom of this a small stream of chemicals is pumped from a regulating tank (*b*) into (*a*) and to the bottom of the mixing and settling tower (*c*), 3ft. in diameter. Here the grease from the steam and the sediment from the water accumulate, the thoroughness of the settlement being doubtless due to the heat and to the fact that the new sediment comes in contact with the old. The overflow is led to the bottom of a larger settling tank (*d*), 10ft. × 5ft., and 12ft. 6in. high, from the top of which the feed water is drawn off. This settling tank contains baffles, which are believed to accelerate the precipitation, but heat is doubtless the more important factor, and it would appear advisable to reduce the radiating surfaces of the tanks and to keep them warm.

Composition of Water.	Before Treatment.	After Treatment.	
	Grains.	Grains.	Two samples were analysed, but these cannot be compared, as they were taken at different times, and as the nature of the feed varies considerably. For this reason also the treatment could not be properly adapted. The condition of the boiler using this water was good.
Calcium carbonate	4·275	1·422	
Calcium silicate	2·076	1·241	
Calcium sulphate	4·081	3·830	
Magnesium carbonate	5·836	5·851	
Ferric oxide, &c.	1·088	0·024	
Scale-forming minerals	17·356	12·368	
Sodium chloride	5·598	6·730	
Sodium sulphate	3·901	4·164	
Soluble salts	9·499	10·894	
Total mineral matter	26·855	23·262	
Carbonic acid gas	0·98*	1·79	
Oxygen gas	0·56	0·66	
Treatment required 0·25 lbs. lime, 0·35 lbs. caustic soda, per 1,000 gallons.			

* This small amount of $C O_2$ is due to the water supplied being hot

Brunn-Lowener Continuous Water Softener. (*See Fig. 11*). —One installation (*J*) was visited; although no samples were obtained it seemed to be working satisfactorily.

J. The lime and soda ash, in proper proportions, together with a certain quantity of water, are placed in (*a*) the chemical tank. It is of semi-cylindrical shape, and has a blade which every now and then stirs up the milky mixture. The water supply is run into (*b*), a measuring tip, consisting of two triangular troughs; when one is

full it tips over and allows the other to fill; while tipping it moves the stirrer in (*a*) and also momentarily opens a little valve in the bottom of this tank (*a*), which allows a definite quantity of chemical to be discharged. This and the water from the tip falls into (*c*) the mixer, and from there they flow into (*d*) the settling tower, the sediment remaining at the bottom, and the nearly clear water passes through the filter to the feed tank. The arrangement would be an ideal one if the quantity of chemicals discharged through the valve each time the tip moves could be made independent of the depth of the milky fluid in (*a*). A spoon for measuring out the chemicals, either fluid or dry, would seem to be more suitable.

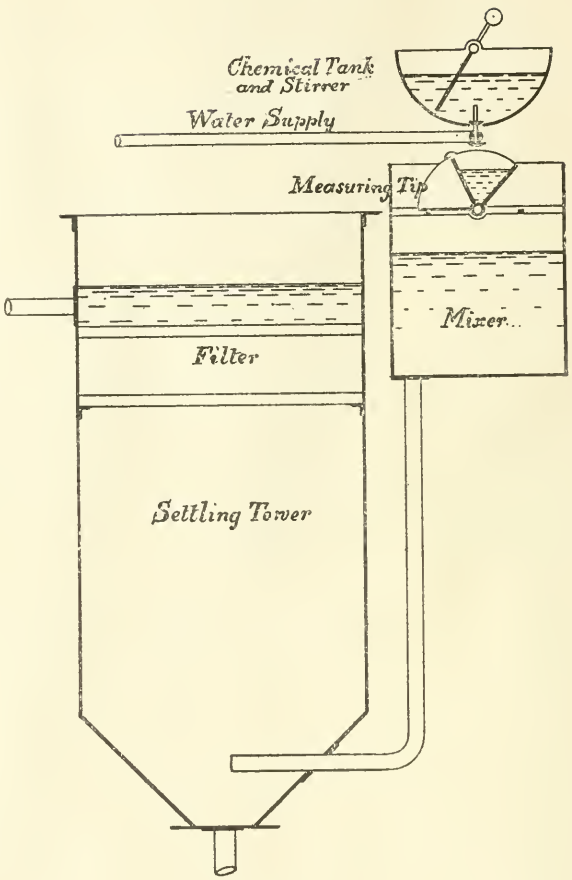

FIG. 11.

DESRUMAUX CONTINUOUS WATER SOFTENER. (*See Fig. 12*).—Two installations (*K* and *L*) were visited. Their main feature is that the motive power to be got out of the water supply is employed to turn a small water wheel which agitates the water in the lime tower, and in the newer forms it also serves to measure out the desired quantities of soda solution.

K. The water enters a small regulating tank (*a*) with two nozzles, one discharging through a hollow shaft to the bottom of (*b*) the lime tower, which is 39in. diam. and 12ft. high, and the other discharging over the water wheel into (*d*) the mixing tank, which also receives a steady stream of soda solution from a tank (*c*). The water passes from the mixer (*d*) to the bottom of (*e*) the settling tower and filter, which is 8ft. 3in. diam. and 22ft. high. This

installation treated nearly 3,000 gallons per hour, and reduced the hardness from 38 grains to about 2 grains, but no samples were taken.

L. This installation had only just been erected, and was not working. The lime tower is 8ft. 4in. diam., and the settling tower and filter is 18ft. 6in. diam. and about 46ft. high. This apparatus is intended to treat 60,000 gallons per hour.

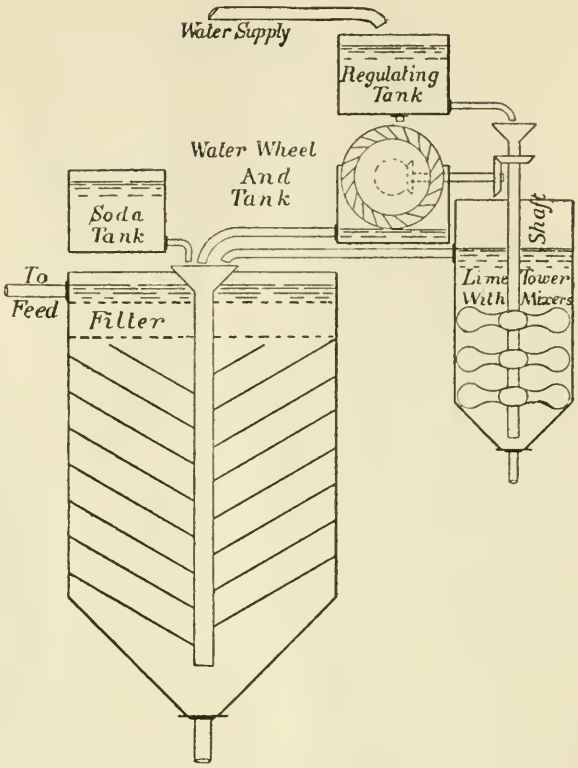

FIG. 12.

REISERT CONTINUOUS WATER SOFTENER AND FEED HEATER was not seen at work, but as it contains several novel features it is here mentioned. In one apparatus the temporary hardness is removed by intense boiling, and the permanent hardness is removed by the addition of carbonate of soda. The apparatus shown in Fig. 13 treats the water by the cold process. The water supply

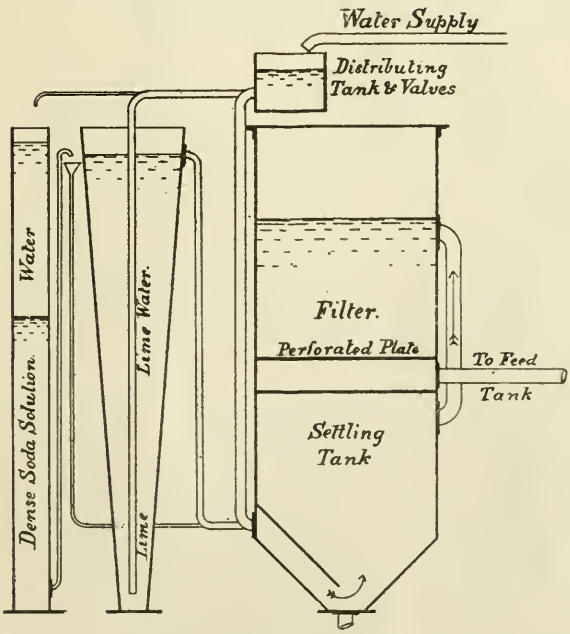

FIG. 13.

enters the distribution tank (*a*), which has three accurately-bored nozzles. One discharges into (*b*) the soda tower, the other into (*c*) the lime tower, and the third into the bottom of (*d*) the settling tank and filter. Every day the soda tower (*b*) is emptied and refilled with strong soda ash solution of a given density; while working water from (*a*) runs into the top of this tower (*b*), and causes the dense soda solution to overflow into a funnel and through a pipe to the bottom of (*d*), where it mixes with the water supply. Into the tower (*c*) a given quantity of burnt lime is every day introduced, and a regulated supply of water, entering at the bottom, makes saturated lime water; the clear overflowing lime water also enters at the bottom of (*d*). Here both chemical solutions mix with the remainder of the water supply, and the precipitate formed lodges in the bottom. The partially-clarified water passes to the top of this tank, which, as will be seen, has a filter across its middle, and the water then flows away to the feed tank. By an ingenious arrangement the current through the filter is momentarily reversed when the sediment in the filter has grown too thick and requires washing out.

Archbutt-Deeley Water Softener (*See Fig. 14*), unlike any of the previous ones, works intermittently, and therefore two settling

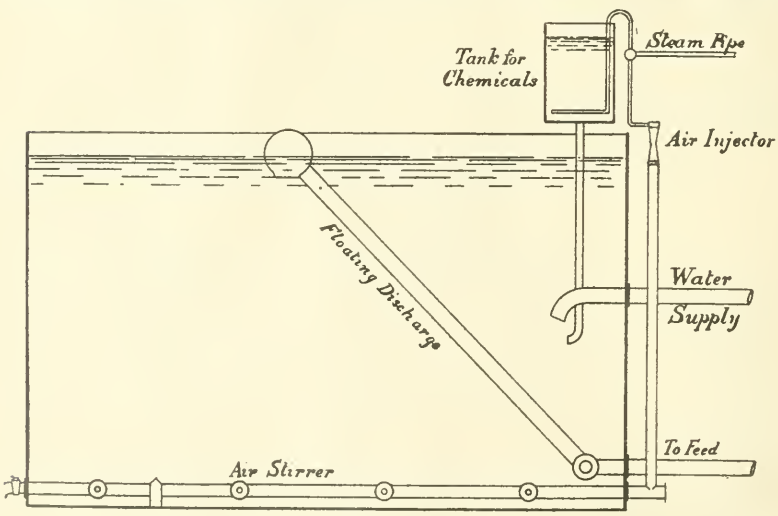

Fig. 14.

tanks are necessary, unless the softening is done overnight, or unless the water when purified is run into a storage tank.

Four installations (*M*, *N*, *O*, *P*) were visited.

M. This installation treated about 2,500 gallons at a time, or about 1,000 gallons per hour. There is a small tank (*a*) into which weighed quantities of lime and soda ash are placed, to which water is added, and steam is then turned on till these chemicals are boiling. The water supply is turned on to the large mixing and settling tank (*b*), 8ft. cubed, and when full the chemicals from (*a*) are run in. Steam is

now turned into the air injector, which drives air through the air stirrer pipes in the bottom of the settling tanks, whereby a thorough mixing of the water, chemicals, and old sediment is effected. The new sediment adheres to the old, and during the following period of rest is quickly precipitated. When the upper layers of the water are clear they are drawn off by means of the floating discharge. This stands in connection with a coke stove, and in passing out the water absorbs some carbonic acid, which, combining with the, as yet, unprecipitated lime in the water, makes it permanently clear. The water is now run into a storage tank of 5,500 gallons capacity, and is from there drawn off by the feed pump. The cost of this installation was stated to be from £150 to £200. About 16 tanks are softened per week; of these only eight are carbonated by contact with the stove gases. The analysis of the water before and after treatment is given in the following table. As will be seen, the result compares favourably with the previously mentioned processes, but, unfortunately, in no case except this can the chemical treatment have been a correct one, and a comparison is therefore valueless. It should, however, be noted that an intermittent process like this one, which will not work unless chemicals are weighed out and boiled, and unless the apparatus is attended to, is more likely to be kept in working order than one of the continuous softeners which, as the attendant will soon find out, delivers water, no matter what the quality, quite independent of any attention. In careful hands, however, the continuous workers should cost less for attendance.

Composition of Water.	Before Treatment.	After Treatment.	Change.
	Grains.	Grains.	Grains.
Calcium carbonate	6·659	1·704	4·955 loss
Calcium silicate	1·733	1·175	0·558 loss
Calcium sulphate	2·639	0·0	2·639 loss
Magnesium carbonate	5·418	0·073	5·345 loss
Ferric oxide, etc.	0·330	0·148	0·182 loss
Scale-forming minerals	16·779	3·100	13·679 loss
Magnesium chloride	0·251	0·0	0·251 loss
Sodium chloride	2·675	3·211	0·536 gain
Sodium carbonate	0·0	0·883	0·883 gain
Sodium sulphate	0·0	5·402	5·402 gain
Soluble salts	2·926	9·496	6·570 gain
Total mineral matter	19·705	12·596	7·109 loss
Carbonic acid gas	7·161	1·00*	6·161 loss
Oxygen gas	0·66	0·66	0·0

Treatment required, lime, 1·9 lbs., soda ash, 0·35 lb. per 1,000 gallons. Treatment adopted, lime, 2·5 lbs., soda ash, 0·60 lb. Alumino ferric, 0·15 lb. per 1,000 gallons.

* NOTE.—This sample was not carbonated. Carbonating increased the CO_2 to 6·3 grains.

The above treatment seems to be a correct one. The discrepancies between treatments required and adopted being due to impurities in the lime, and the addition of alumina ferric, which requires more soda and lime.

N. This installation can treat about 8,000 gallons at a time, or about 3,000 gallons per hour. The mixing and settling tank measures 12ft. 3in. square by 10ft. deep. The pure water is run into a large storage tank. The boiling and agitation in the large tank takes 10 minutes, the settling about one hour, and the running out about another hour. At these works the carbonater is used only once a week, in the belief that this will keep the pipes free from scale. The reagents used are 6 lbs. lime and $1\frac{1}{4}$ lbs. soda ash per tank of 8,000 gallons. The water is usually tested once a week, or when there is a change of weather. The cost of this apparatus was £296.

O. The mixing and settling tank of this installation measures 10ft. square by 8ft. deep. It cost £150, and treats about 3,000 gallons per hour. Only lime is used as a chemical, and the hardness is reduced from 32 to 16 grains. The attendant's labour amounted to about four hours per day. The clear water was not brought in contact with carbonic acid.

P. This installation is nine years old, and treats 24,000 gallons at a time, the tank measuring 24ft. square and 10ft. deep. The water is not carbonated. Its hardness is reduced from 13·3 to 7·1 grains.

The opinion of Mr. Baron, our chemist, is that the Archbutt-Deeley Apparatus, and several of the more refined continuous water softeners, particularly if the treated waters are heated, should give excellent results, provided correct instructions are given as regards quantities of lime and soda to be added, and provided also that rough chemical tests are occasionally made to ascertain the hardness of the water before and after treatment. The idea of having to make such tests may deter some from adopting water softeners, but, as will be seen by the following brief description, the simple tests for hardness can be carried out by anybody.

CHEMICAL TESTS.

Soap Test for Total Hardness.

A standard solution of soap (which can be bought) is prepared by dissolving soap in water and checking it against water of standard hardness.

A small quantity of water to be tested is measured and poured into a glass-stoppered bottle; a small quantity of standard soap solution is added and the mixture then shaken. At first the water contains too much hardness to form a lather, but as more and

more soap is added it gets softer, and lather is formed which does not disappear on standing. The quantity of standard soap solution added is the measure of the

I. TOTAL HARDNESS of the water.

II. THE PERMANENT HARDNESS is determined cold by the soap test after first boiling the water for a long time so as to remove all temporary hardness. The difference of I. and II. is the temporary hardness, but this test is not very accurate. It is better to test for

III. TEMPORARY HARDNESS as follows. A standard acid solution (which can be bought) is prepared by mixing a given quantity of pure acid with water. A small quantity of water to be tested is measured into a white bowl, and one drop of an aniline dye, called methyl orange, is added, and then small quantities of standard acid are poured in until the yellow colour of the dye changes into a red one. The quantity of standard acid added is the measure of the TEMPORARY HARDNESS and the permanent hardness is the difference of I. and III.

Roughly speaking, the degrees of temporary hardness fix the amount of lime or caustic soda to be used, and the degrees of permanent hardness fix the amount of soda-ash to be used.

From the preceding remarks on the 15 water-softening installations visited, and from other information, it would appear that, roughly speaking, the cost of the plant per 1,000 gallons treated per hour would be from £100 to £150, and as 750 gallons per hour is about as much as one 8ft. Lancashire boiler can evaporate, it will be seen that it is cheaper to adopt a water softener than to lay down a spare boiler, if only one boiler is in use; and even if there are six boilers the advantage would still be with the softening plant on account of lesser cost of the chemicals which could then be used, and the saving in the cost of scaling

Experiments on corrosion are now in progress, and it is hoped soon to obtain definite results on this very important subject.

I am, Gentlemen,

Yours faithfully,

C. E. STROMEYER,

Chief Engineer.

Manchester Steam Users' Association,

9, Mount Street, Manchester.

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